(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 154 404 B1**

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **12.06.91** (51) Int. Cl.[5]: **G06F 15/68**, G06F 15/62

(21) Application number: **85300648.4**

(22) Date of filing: **30.01.85**

(54) **Processing system for aligning two picture images.**

(30) Priority: **24.02.84 JP 33581/84**

(43) Date of publication of application:
11.09.85 Bulletin 85/37

(45) Publication of the grant of the patent:
12.06.91 Bulletin 91/24

(84) Designated Contracting States:
DE FR GB NL

(56) References cited:

PATENT ABSTRACTS OF JAPAN, vol. 8, no. 153 (P-287)[1590], 17th July 1984; & JP-A-59 52 359 (HITACHI MEDEIKO K.K.) 26-03-1984

(73) Proprietor: **KABUSHIKI KAISHA TOSHIBA**
72, Horikawa-cho Saiwai-ku
Kawasaki-shi Kanagawa-ken 210(JP)

(72) Inventor: **Watanabe, Mutsumi c/o Patent Division**
Kabushiki Kaisha Toshiba 1-1 Shibara 1-chome
Minato-ku Tokyo 105(JP)

(74) Representative: **Freed, Arthur Woolf et al**
MARKS & CLERK 57-60 Lincoln's Inn Fields
London WC2A 3LS(GB)

EP 0 154 404 B1

Description

The present invention relates in general to an image processing technique and, more particularly, to a technique of aligning a plurality of picture images for image synthesis.

Recently, it has become important to synthesize a plurality of picture images, for example, two images picked up at different times. Some image processes apply to a medical imaging system such as a computed tomography (CT) scanner, which obtains an image of a selected plane section of a human body. One of these image processes obtains the difference between two images of a region of interest (e.g., an affected part) in the selected plane section in order to more clearly show a change in such a region over a period of time. Such an image process, considered as one of picture image synthesis, requires the precise alignment of two images to produce a subtraction image. Poor image alignment cannot result in a good subtraction image.

The simplest image alignment is based on the visual judgement of a human being. This alignment involves the comparison of two images, detection of misalignment (or mis-registration) between them, and transition of one of the images according to the misalignment. The image transition includes a simple coordinate conversion such as parallel transition, rotation, enlargement and reduction. This alignment technique is relatively effective when the misalignment, which is expressed in a vector quantity, is uniform over the entire image plane. A single picture image obtained for medical purposes (or a single satellite-transmitted picture image) is usually a complex of different sub-regions of an object so that the vector of the misalignment between two such picture images is hardly uniform over the entire image plane. That is, regional variations in misalignment vector often appear. In this case, the simple coordinate conversion technique cannot be effective in aligning two images over the entire image plane.

There is a known method for solving the problem. This method includes the steps of:

1) Dividing both picture images of an object into several sub-image regions.

2) Computing a correlation coefficient for each pair of corresponding sub-image regions of two picture images.

3) Detecting the misalignment vector between that pair of sub-image regions which has the maximum correlation coefficient.

4) Obtaining the misalignment over the entire image based on the detected vector.

According to this method, however, when the misalignment between corresponding sub-image regions is significantly small or a contrast difference between two images is small, the variation in the correlation coefficients is considerably small. This reduces the detection sensitivity of the misalignment vector and deteriorates alignment accuracy as a consequence. In this case, if the images have noise components, the significance of the variation in the correlation coefficients may be counteracted. Such an adverse effect of the noise greatly decreases the alignment accuracy and may result in alignment error at the worst.

It is therefore an object of the present invention to provide a new and improved image processing technique for aligning, with higher accuracy, a pair of picture images such as those used for medical purposes or satellite-transmission.

It is another object of the present invention to provide a new and improved self-alignment technique for aligning a pair of such picture images with higher accuracy at higher speed.

According to the image self-alignment system of the present invention, first, a desired image region is extracted from each of a pair of picture images to be aligned. Each image region is divided into n x m image segments arranged in a matrix form, where n and m are positive integers. There are two steps in detecting misalignment between each pair of image segments to be compared. The first one (coarse misalignment detection mode) uses a first evaluation parameter called a correlation coefficient for rough misalignment detection. The other (fine misalignment detection mode) uses a second evaluation parameter including data of the difference in pixel density for fine misalignment detection. Based on the final misalignment data between each image segment pair, which has been obtained with higher accuracy in these two modes, alignment between the associated two picture images is automatically performed.

The present invention is best understood by reference to the accompanying drawings, in which:

Fig. 1 is a block diagram showing the overall configuration of an image alignment device according to one embodiment of this invention;

Fig. 2 is a block diagram illustrating the interior of a partial image area designating unit provided in the image alignment device of Fig. 1;

Fig. 3 is a block diagram depicting a detailed circuit configuration of a misalignment detecting unit provided in the image alignment device of Fig. 1; and

Fig. 4 is a block diagram showing the interior of a misalignment correcting unit provided in the image alignment device of Fig. 1.

With reference to Fig. 1, an automatic image alignment system according to one embodiment of the present invention will now be described. Fig. 1 exemplifies main units of the image alignment de-

vice and a process sequence of image data associated with these units.

In Fig. 1, a pair of picture images 10, 12, such as medical-purpose reconstructed tomographic images of a person, is subjected to image alignment. First, these images 10, 12 are supplied to a partial image area designator 14 which specifies desired partial image areas 10a, 12a in the respective images 10, 12. These partial image areas 10a, 12a are selected so as to include a characteristic that is relatively clear for detecting the overall misalignment of the image pair 10, 12. The "relatively clear characteristic" means a clearer difference in pixel density and higher contrast. For example, for medical purposes, an image area of the contour of a bone would be considered better qualified as the one with such e characteristic than that of soft tissues of organs.

According to this embodiment, the partial image areas 10a, 12a are specified by visual comparison by an operetor es follows.

The partial image area designator 14 comprises e display terminal 16 for image display (see Fig. 2). When the operator inputs en instruction to display the imeges 10, 12 vía a keyboard 18, the imeges 10, 12 are reed out from a image filing unit 20 incorporating a recording medium such as a magnetic disk. The images 10, 12 are then transferred to the display terminal 16 under the control of a display controller 22. As shown in Fig. 2, the images 10, 12 to be aligned are simultaneously displeyed on the screen of the display terminal 16. This facilitetes visual comparison of those images by the operator. Then, the operator menipuletes a specific key (not shown) on the keyboard 18 to move rectangular cursors K1 and K2 on the screen to desired locations (the partial image areas 10a, 12a) on the images 10, 12. The movement of the cursors K1, K2 is controlled by a cursor controller 24 connected to the keyboard 18. Each cursor hes the same area as to-be-selected partial image ereas. Consequently, the areas on the picture images 10, 12 occupied by the cursors K directly become the partial image areas 10a, 12a. This permits the operator to extract desired partial image areas on the associated images 10, 12 in real time.

The partial image areas 10a, 12a, designated by the partial image area designator 14, are supplied to a processor unit 30 where each partial image area is divided into a plurality of image units or segments. For this function, the processor unit 30 is called a partial image area divider hereafter. The image segments (n x m segments) of the partial image area 10a are expressed by "P_{nm}," and those of the partial image area 12a are expressed by "Q_{nm}." Those segments are affixed with matrix coordinates, which are used to manage each pair of corresponding image segments which are included in the respective partial image areas 10a, 12a.

Again in Fig. 1, a misalignment detecting unit 40 is located at the subsequent stage of the partial image area divider 30. The misalignment detecting unit 40 comprises a segment pair designator 42 and a misalignment calculating unit 44. The segment pair designator 42 sequentially designates segment pairs, one from each partial image area (10a, 12a), e.g., P_{11} and Q_{11}, P_{12} and Q_{12}, ..., P_{ij} and Q_{ij}. The misalignment calculating unit 44 computes a misalignment vector between each designated segment pair, for exmaple, P_{ij} and Q_{ij}. This computation is based on an evaluation function with two different parameters, a correlation coefficient between the corresponding image segments P_{ij}, Q_{ij} and e pixel density difference coefficient that is the sum of the absolute value of the difference in pixel densities between corresponding portions of the designated segment pair. (These parameters ere hereafter called correlation data and pixel density difference data.) The misalignment vector for the first image segment peir, P_{11} and Q_{11}, is calculated based on the evaluation function, and is supplied to a memory (to be described later). Then, the next image segment peir, e.g., P_{12} and Q_{12}, is specified by the segment pair designator 42. The misalignment vector for this segment pair is calculated by the calculating unit 44 end is stored in the memory. The same calculation process is executed for every one of the associated image segment pairs, thus providing e plurality of misalignment vector data for the partial image areas (10a, 12a). These plural pieces of misalignment vector date are supplied to an image position correcting unit 50, which extracts reliable ones from the vector data for overall alignment of the picture images 10, 12. This unit 50 can also partially correct the picture images with e divided picture segment of an image plane used as a unit, as desired.

Fig. 3 is a detailed illustration of the interior of the misalignment detecting unit 40. The segment pair designator 42 is connected to an initial address memory 60 and address controllers 62, 64. The memory 60 stores center eddresses of the partial image areas 10a, 12a. The address controller 62 (P_{ij} address controller) stores data of the sizes (unit areas) of image segments P_{ij} of the partial image area 10a and center addresses of the individual segments. The other address controller 64 (Q_{ij} address controller) stores center address data and size data of image segments Q_{ij} of the partial image area 12a.

The P_{ij} address controller 62 is coupled to a P_{ij} image segment memory 68 through a first image memory 66, which stores the first image picture 10.

Based on the address data, the p_{ij} address controller 62 reads out the image picture from the first image memory 66 and extracts a specific image segment P_{ij}. The extracted image segment P_{ij} is stored in the image segment memory 68. The Q_{ij} address controller 64 supplies the size data and central address data of an image segment Q_{ij} of the second image picture 12 to a neighboring region designator 72 under the control of a coarse misalignment detecting circuit 70. The neighboring region designator 72 extracts an image segment with the specified size and the specified address being in the center from the image picture 12 stored in a second image memory 74. The extracted image segment Q_{ij} is stored in a segment memory 76 (Q_{ij} image segment memory) coupled to the second image memory 74. This pair of image segments P_{ij} and Q_{ij}, respectively stored in the image segment memories 68, 76, is used for detection of the misalignment vector between the image pictures 10, 12 and position correction.

Each of the image memories 68, 76 is coupled to calculators 80, 82. The calculator 80 sequentially calculates the correlation data, i.e., the first evaluation parameter, while the calculator 82 sequentially calculates the pixel density difference data (the second evaluation parameter). The image segment information stored in each of the image memories 68, 76 is parallel-transmitted to those calculators 80, 82, which, in turn, respectively calculate the correlation data and pixel density difference data for the image segment pair P_{ij} and Q_{ij}. The calculated correlation data and pixel density difference data are respectively stored in a correlation data memory 84 and a pixel density difference memory 86. This data process is repeated for neighboring regions around the image segment designated by the neighboring region designator 72. That is, while shifting the image segment Q_{ij} by a small amount on the image plane around the initial position, the correlation data between the image segment Q_{ij} and image segment P_{ij} - (stationary) is sequentially calculated.

The correlation data calculator 80 and correlation data memory 64 are included in the coarse misalignment detecting circuit 70. The memory 84 is coupled to a maximum detector 90, which detects the maximum correlation data among those stored in the memory 84 and generates an address signal 92 representing the center address of the image segment (Q_{ij}') having the maximum correlation data. The correlation coefficient between the image segment P_{ij}, and the image segment Q_{ij}' within the shifting range of the segment Q_{ij}, is maximum.

The address signal 92 is transmitted to the Q_{ij} address controller 64 through a switch 94 that is in a first electrical mode as shown in Fig. 3. The Q_{ij} address controller 64 supplies new center address data of the neighbouring image segment Q_{ij}' to the neighboring region designator 72 and a displacement calculator 96, which is coupled to the initial address memory 60 and the Q_{ij} address controller 64. The displacement calculator 96 calculates the displacement between the center address of the initial image segment Q_{ij}, stored in the initial address memory 60, and the center address of the image segment Q_{ij}', represented by the signal 92 obtained in the coarse misalignment detecting circuit 70. The displacement or displacement vector data between the center addresses of the image segments Q_{ij} and Q_{ij}' is stored in a displacement memory 98. Based on the calculated displacement, the Q_{ij} address controller 64 supplies the new center address data of the image segment Q_{ij} to the neighboring region designator 72.

The coarse misalignment detecting circuit 70 includes a switch controller 100; which detects the maximum (converged) correlation data among the all the correlation data obtained with the image segment Q_{ij} being shifted around. At this time, the detecting circuit 70 controls the switch 94 to prevent the supply of the address signal 92 to the Q_{ij} address controller 64. In the case where the correlation coefficients between the image segment pair P_{ij}, Q_{ij} are sequentially calculated for the segment Q_{ij} being shifted, a gradual decrease in a change in the calculated correlation data can mean that the correlation data is approaching (or converging with) the maximum correlation data. When the variation in the correlation data over a period of time falls below a predetermined threshold level, i.e., when the maximum correlation data is converged, the switch controller 100 switches the switch 94 to end the coarse misalignment detection mode. The switch controller 100 serves to maintain the coarse misalignment detection (first misalignment detection) for the image segment pair P_{ij}, Q_{ij} as long as the change in the correlation data is above the threshold level. When the change in the correlation data for the image segment pair P_{ij}, Q_{ij} decreases to fall below the threshold level, the coarse misalignment detection is completed and the fine misalignment detection (second misalignment detection) starts. In this embodiment, the fine misalignment detection further uses the pixel density difference data (the second evaluation parameter). The following description discusses the arrangement of the switch controller 100 and explains the fine misalignment detection.

A variation calculator 102 is connected to the maximum detector 90 to sequentially calculate temporal changes in the maximum coefficient data for the associated image segment pair. The obtained data of the temporal changes in the maximum coefficient data is supplied to a data com-

parator 104 connected to a threshold value generator 106 that prestores the threshold value 108. The comparator 104 compares the reference threshold value 108 with the variation in the maximum correlation data that is an actual value. When the variation becomes smaller than the threshold value, the comparator 104 supplies a changeover instruction signal to a switch driver 110, which is connected to the switch 94. In response to this signal, the switch driver 110 switches the switch 94 from the first electrical mode to a second electrical mode, which prevents the address signal 92 of the coarse misalignment detecting circuit 70 from passing the switch 94. This completes the coarse misalignment detection.

Suppose the evaluation parameter or evaluation function used in the fine misalignment detection is represented by "P(xy)" which is given by:

$P(xy) = S(xy) - kx \cdot E(xy)$,

where S(xy):	data obtained by normalizing the correlation data calculated in the correlation data calculator 80,
E(xy):	data obtained by normalizing the pixel density difference data,
x, y:	coordination on the image plane,
kx:	weighing parameter (positive).

The greater S(xy) or the smaller E(xy) is, the greater thus the defined function P(xy) becomes. P(xy) has a maximum of 1.0 only when the image segment pair matches ideally.

Two normalizer circuits 112 and 114 are respectively coupled to the correlation data calculator 80 and pixel density difference data calculator 82. The normalizers 112, 114 serve to compute the normalized data S(xy) and E(xy) based on the data from the calculators 80, 82. The normalizers 112 and 114 supply the data S(xy) and E(xy) to a subtractor circuit 116, which performs a subtraction on s(xy) and E(xy) to obtain the evaluation function P(xy) for fine misalignment detection. Thus attained P(xy) is stored, together with the center address (X, Y) of the corresponding neighboring region, in a memory 118 located at the succeeding stage of the subtractor 116.

This process of obtaining P(xy) is repeated wherein one image segment Q_{ij}' of the image segment pair, the coarse alignment detection of which has been completed, is finely shifted on the same image plane under the control of the Q_{ij} address controller. Plural pieces of evaluation function data P(xy) obtained in each process are sequentially stored in the memory 118. A second maximum detector 120 coupled to the memory 118 detects the maximum one, P(xy)max, among the stored P(xy) and generates a second address signal 122 representing the center address of an image segment Q_{ij}'' which has yielded P(xy)max. This address signal 122 is fed back to the Q_{ij} address controller 64 via the switch 94 in the second electrical mode. Like in the coarse misalignment detection mode, the displacement calculator 96 calculates the displacement between the initial center address and the center address of the image segment Q_{ij}''.

The maximum detector 120 is connected to a comparator 124 connected to a threshold value generator 126, which prestores a threshold value 128 for the evaluation function. The comparator 124 compares the threshold value 128 with evaluation function data that is an actual value. When the change in the actual evaluation function data increases to rise above the threshold value, it can be considered that a final matching between the associated image segments P_{ij}, Q_{ij}'' has substantially occurred. Thus, the comparator 124 supplies a misalignment detection end signal 132 to a switch driver 130 connected to the switch 94. In response to the signal 132. the switch 94 changes to the original electrical mode from the second electrical mode. This completed the fine misalignment detection and makes the image processing device ready for the coarse misalignment detection for the next image segment pair. for example. $P_{i+1,j}$ and $Q_{i+1,j}$.

The switch driver 130, operable in the fine alignment detection mode, is coupled to three transmission switches S1, S2, S3. The first data transmission switch S1 is provided between the correlation data memory 84 and final (converged) correlation data memory 140 having correlation data relating to each optimum Q_{ij}'. This memory 140 exclusively stores final correlation data (converged in the coarse misalignment detection mode) with address data specifying the image segment pair which has yielded the final correlation data. The second data transmission switch S2 is provided between the pixel density difference data memory 86 and a final (converged) pixel density difference data memory 142 having pixel density data relating to each optimum Q_{ij}''. The memory 142 exclusively stores converged pixel density difference data, which is also affixed with address data specifying the image segment pair that has yielded that pixel density difference data. The third data transmission switch S3 is provided between the displacement memory 98 and final misalignment data memory 144. This memory 144 exclusively stores misalignment vector data finally yielded through the coarse and fine misalignment detection modes. This misalignment vector data is also affixed with address data specifying the image segment pair which has yielded that particular vector data. These switches S1, S2, S3 become con-

ductive in response to the misalignment detection end signal 132 from the switch driver 130. Therefore, upon completion of the fine misalignment detection, all the final data is stored in the memories 140, 142, 144.

The misalignment detection for the next image segment pair, e.g., $P_{i+1,j}$ and $Q_{i+1,j}$, is also carried out in two steps; namely, the coarse and fine misalignment detection modes. These two steps are repeated for every corresponding image segment pair of the partial image areas 10a, 12a. As a result, regional misalignment vector data for every image segment pair (P_{11}, Q_{11}), ..., (P_{ij}, Q_{ij}), ..., (P_{nm}, Q_{nm}) can be obtained.

The image position correcting unit 50 determines an optimum alignment for the picture images 10, 12 based on the regional misalignment quantities between these picture images, i.e., misalignment quantities between all the image segment pairs. The following is an explanation of the position correction executed by the unit 50.

Fig. 4 is a detailed illustration of the interior of the position correcting unit 50. The position correcting unit 50 includes a reliable misalignment data search circuit 148 which searches plural pieces of misalignment vector data, obtained by repeating the misalignment detection for all the image segment pairs, for the one with the highest reliability. As shown in Fig. 4, the search circuit 148 includes two sorting circuits 150, 152 which are respectively coupled to the converged correlation data memory 140 and the converged pixel density difference data memory 142. The sorting circuit 150 receives plural pieces of converged or final correlation data for plural pieces of image segment pairs P_{ij}, Q_{ij} and sorts the correlation data in order from the largest to the smallest, thus providing a hierarchical sequential organization. Consequently, the correlation data is stored in a hierarchic memory 154, located at the succeeding stage of the sorting circuit 150, in order from the largest to the smallest. This forms a hierarchic structure for the plural pieces of correlation data obtained for the corresponding image segment pairs P_{ij}, Q_{ij} of the partial image areas 10a, 12a. The other sorting circuit 152 receives plural pieces of converged or final pixel density difference data for the same plural pieces of image segment pairs P_{ij}, Q_{ij} and sorts the pixel density difference data in order from the smallest to the largest. Therefore, the pixel density difference data is stored in another hierarchic memory 156, located at the succeeding stage of the sorting circuit 152, in order from the smallest to the largest. This forms a hierarchic structure for the plural pieces of pixel density difference data obtained for the corresponding image segment pairs P_{ij}, Q_{ij} of the partial image areas 10a, 12a.

An AND circuit 158, coupled to the hierarchic memories 154 and 156, searches the correlation data and pixel density difference data stored in these memories for the ones which are within a specific high rank and specify a common image segment pair. Assume that the specific rank is the highest 5 data in the hierarchic memories 154 and 156. If there exists an image segment pair that has both the correlation data and pixel density difference data ranked at the top in those memories 154, 156, this pair is considered to have yielded a misalignment vector with the highest reliability. Naturally, that image segment pair would be selected without reservation. If there exists an image segment pair which has the correlation data ranked as the second best in the hierarchic memory 154 and the pixel density difference data ranked as the third in the hierarchic memory 156, this pair is also selected because the misalignment vector of such a pair is considered to have a relatively high reliability. An image segment pair with the best correlation data or pixel density difference data but the other data being ranked below the fifth would not be selected. For example, an image segment pair with the best correlation data but with the seventh rank pixel density difference data would not be selected. A memory 160 coupled to the AND circuit 158 exclusively stores the positions in the hierarchic memories 154, 156, of the thus selected image segment pair. This sorting manner provides an image segment pair or pairs with a higher correlation coefficient and a smaller sum of the absolute values of pixel density differences. It can be said that the misalignment vector data obtained for the selected image segment pair (or pairs) has a high reliability.

A position-adjusting address controller 162 is coupled to the final misalignment data memory 144 shown in Fig. 3. This controller 162 finds out the position data of the image segment pair (or pairs) having the highly-reliable misalignment data stored in the memory 160 and accesses the memory 144 to extract the final or converged misalignment data that is actually calculated for the concerned image segment pair (or pairs). Based on the reliable misalignment data, the address controller 162, which is also coupled to the image memories 66 and 74, compensates for the misalignment between the image pictures 10, 12. When the extracted partial image areas 10a, 12a are regions of interest for a medical examination, a fine misalignment compensation can be performed on those image areas 10a and 12a. When the misalignment between the original image pictures is considered uniform over the entire picture plane, the overall alignment of the image pictures 10, 12 can be accurately carried out based on the mean vector of the selected reliable misalignment data.

According to the imaging system incorporating

the image alignment apparatus embodying the present invention, first, desired partial image areas 10a, 12a, which interest an operator or include clear properties, are extracted from a pair of targets, i.e., image pictures 10, 12. Each of the extracted areas 10a, 12a is divided into a plurality of image segments arranged in a matrix form. An arbitrary pair of segments (P_{ij}, Q_{ij}) corresponding to each other is selected from among these image segments and the misalignment vector between the pair is then calculated. After the misalignment vector calculation is completed for one image segment pair, a final misalignment vector is stored in the memory 144. Then, the same misalignment vector calculation is taken with the next image segment pair until all the image segment pairs are involved.

It should be noted that the misalignment detection for each pair of corresponding image segments is performed in two steps. The first step is the coarse misalignment detection mode in which the detection is carried out based on the correlation data for the image segment pair calculated as one of the pair is shifted around on the image plane. The second step is the fine misalignment detection mode in which the detection is carried out based on the evaluation function P(xy) and further depending on the pixel density difference data between the image segment pair. These two steps, involving not only the correlation data but also the pixel density difference data as two evaluation parameters, will yield significantly reliable final misalignment vector information. The coarse detection mode is switched to the fine mode when the variation in the correlation data updeted in the coarse misalignment detecting circuit 70 falls below a specific reference level or threshold level. Such e level is set by the threshold value generator 106 included in the coarse miselignment detecting circuit 70.

It can be said that the matching of the image segment pair has been approximately detected at the time the correlation data between the pair reaches the threshold level. Therefore, the misalignment vector can be obtained by calculating the displacement between the center coordinations of the image segments. However, the present invention does not stop the detection at this stage but goes further into a finer misalignment detection. A new evaluation function based on the correlation data and pixel density difference data is introduced in the fine detection mode, thus ensuring finer detection of alignment between the associated image segment pair. The above-discussed point is one important technical feature of the present invention.

Another important feature resides in that one piece of misalignment vector data with a significantly high reliability is selected from the plural pieces of misalignment vector data obtained by repeating the aforementioned detection procedures for every image segment pair. The correlation data and pixel density difference data of each image segment pair are separately sorted to search for an image segment pair (or pairs) with good characteristics in both data. The segment pair or pairs are extracted as being significantly reliable. As a result, an accuracy in detecting regional misalignment vectors between the partial image areas 10a, 12a, i.e., regions of interest, can further be improved. Therefore, even when the misalignment vector between medical-purpose picture images or satellite-transmitted images is uniform over the entire image plane, accurate alignment can be realized for at least a part of a region of interest. Further, even when noise is included in the partial image areas 10a, 12a, the process of selecting image segment pairs with high reliability cen exclude those with lower reliability resulting from noise. This provides e highly accurate and reliable image alignment process which is substantially free of adverse noise effects. This further improves image synthesis. Thus, the image position alignment technique of the present invention can significantly contribute to image synthesis used in medical purposes, satellite-image processing, etc.

Although the present invention hes been shown and described with reference to a particular embodiment, various changes end modifications which ere obvious to any persons skilled in the art to which the invention perteins are deemed to lie within the scope of the invention.

For example, the evaluation function for specifying the quantity of a misalignment may be a combination of other indices than the correlation coefficient end pixel density difference which also represent the quantity image alignment. In the aforementioned embodiment, the information of pixel densities is used for the correlation coefficient and pixel density difference. However, when a distinctive common characteristic is obviously seen between two image pictures, the alignment process can be performed paying attention only to that characteristic. In addition, the misalignment vector quantity obtained for each pair of partial image areas with high reliability may be used directly to correct the image position of that particular pair, thus aligning the associated image pictures segment by segment.

Claims

1. An image processing apparatus for aligning a pair of first and second picture images, comprising first processor means (14) for extract-

ing a desired partial image area from each of the first and second images to be subjected to position alignment, and second processor means (30) for dividing each of said partial image areas into n x m image segments (P_{ij}, Q_{ij}) arranged in a matrix form, where n and m are positive integers, characterized in that said apparatus further comprises:
third processor means (40):
in a first mode, for selecting an initial image segment (P_{ij}) of the first image;
for detecting misalignment between said initial image segment (P_{ij}) and a number of image segments (Q_{ij}) of said second image using a first evaluation parameter based upon correlation coefficient data to select en optimum image segment (Q_{ij}') having a given maximum correlation coefficient;
in a second mode, for detecting misalignment between seid initiel imege segment (P_{ij}) and a number of image segments finely shifted ebout said optimum image segment (Q_{ij}') using a second evaluation parameter based upon pixel density difference data and correlation coefficient dete to select the optimum image segment pair (P_{ij}, Q_{ij}'') having e maximum evaluation function (Pxy);
for selecting a further initial image segment (P_{i+j}, j) and repeating said detection in said first and second mode;
for storing misalignment data for each (P_{ij}); and fourth processor meens (50) for selecting at least one optimum image segment pair (P_{ij}, Q_{ij}'') heving the optimum misalignment data and for eligning seid first and second picture images based upon said optimum misalignment data.

2. The apparatus according to claim 1, characterized in that said third processor means comprises:
first calculator means (80) for sequentially calculating said correlation coefficient data, when said first detection mode is carried out, by shifting at least one of said corresponding image segment pairs around an initial position on an image plane in a manner such that each shifting from said initial position makes the image segments before and after the shifting have some overlapping portions therebetween; and
first maximum detector means (90) for determining the maximum correlation data among plural pieces of said correlation data calculated for each pair of said corresponding image segments.

3. The apparatus according to claim 2, characterized in that said third processor means further comprises:
mode controller means (100), connected to said first maximum detector means (90), for electrically storing a threshold value of said correlation data and switching the detection mode from said first detection mode to said second detection mode when a variation in the correlation data between said image segment pairs, sequentially detected, decreases to fall below said threshold value.

4. The apparatus according to claim 3, characterized in that said third processor means further comprises:
second calculator means (82) for summing the magnitudes of pixel density differences for each of said image segment pairs in said second detection mode to produce said pixel density difference data;
normalizer means (112, 114), connected to said first calculator means (80) and second calculator means (82), for normalizing said correlation data and pixel density difference data; and
third calculator means (116), connected to said normalizer means (112, 114), for celculeting said second evaluation parameter besed on said normalized correlation date and pixel density difference data.

5. The epparatus according to claim 4, characterized in that said third processor means further comprises:
second maximum detector means (120) for updating said second evaluation peremeter to determine the maximum among e plurality of said second evaluation peremeters calculated for the particular image segment peir;
mode termination means (124, 130), coupled to said second maximum detector means (120), for electrically storing a threshold value of said second eveluation parameter and terminating said second detection mode performed for the particular image segment pair by said third processor means (40) when said updated second evaluation parameter exceeds said threshold value; and
fourth calculator means (96) for detecting center addresses of each of said optimum image segment pairs and calculating a misalignment between said center addresses.

6. The apparatus according to claim 5, characterized by further comprising fifth processor means (148) for sorting final correlation data and pixel density difference data, which are respectively obtained in said first and second

detection modes for said particular and said optimum image segment pairs of said partial image areas, for searching all of said particular and optimum image segment pairs for at least one image segment pair having both correlation data and pixel density difference data highly ranked and for calculating a misalignment vector between said at least one image segment pair.

7. The apparatus according to claim 6, characterized in that said fifth processor means (148) comprises:
a first hierarchic memory (154) for storing said plural pieces of final correlation data for all of said particular image segment pairs in order from the largest to the smallest;
a second hierarchic memory (156) for storing said plural pieces of final pixel density difference data for all of said optimum image segment pairs in order from the smallest to the largest; and
circuit means (158, 160, 162), coupled to said first and second hierarchic memories, for extracting at least one image segment pair with the correlation data and pixel density difference data both being in a specific high rank and for specifying misalignment vector data of said at least one image segment pair.

8. An image processing method for aligning a pair of first and second picture images, comprising the steps of extracting a desired partial image eree from eech of the first and second picture images to be eligned, and dividing each of said partial image areas into n x m image segments (P_{ij}, Q_{ij}) arrenged in a matrix form, where n x m are positive integers, characterised by further comprising the steps of:
in a first mode, selecting an initial image segment (P_{ij}) of the first image;
detecting miselignment between said initial image segment (P_{ij}) and e number of image segments (Q_{ij}) of said second image using a first evaluation parameter based upon correlation coefficient data to select an optimum image segment (Q_{ij}') having a given maximum correlation coefficient;
in a second mode, detecting misalignment between said initial image segment (P_{ij}) and a number of image segments finely shifted about said optimum image segment (Q_{ij}') using a second evaluation parameter based upon pixel density difference data and correlation coefficient data to select the optimum image segment pair (P_{ij}, Q_{ij}'') having a maximum evaluation function (Pxy);
selecting a further initial image segment (P_{i+1}, j) and repeating said detection in said first and second mode;
storing misalignment data for each (P_{ij}); and
selecting at least one optimum image segment pair (P_{ij}, Q_{ij}'') having the optimum misalignment data and for aligning said first and second picture images based upon said optimum misalignment data.

9. The method according to claim 8, characterised by further comprising a step of repeatedly performing said first and second misalignment detections for the image segment pairs other than said selected image segment pair, thus providing final misalignment vector data for all of said n x m imege segment pairs included in said partial image ereas of said first and second images.

10. The method according to claim 9, characterized by further comprising the steps of:
separately sorting plural pieces of final correlation dete and pixel density difference deta obtained for all of said image segment pairs;
searching said all of said imege segment pairs for et least one image segment peir heving those correlation data and pixel density difference deta which are both in a predetermined high rank; and
specifying the misalignment quantity between said at leest one image segment pair as highly reliable misalignment data and utilizing said specified misalignment quantity for aligning said first and second images.

11. The method according to claim 9, characterized by further comprising the steps of:
sorting said final correlation data in order from the largest to the smallest to form a hierarchic structure for said correlation data;
sorting said final pixel density difference data in order from the smallest to the largest to form a hierarchic structure for said pixel density difference data;
searching all of said image segment pairs for at least one image segment pair having those correlation data and pixel density difference data which are both in a predetermined high rank; and
specifying the misalignment quantity between said at least one image segment pair as highly reliable misalignment data and utilizing said specified misalignment quantity for aligning said first and second images.

Revendications

1. Appareil de traitement d'images pour aligner une paire de première et seconde images, comprenant des premiers moyens de traitement (14) pour extraire une zone d'image partielle désirée de chacune des première et seconde images à soumettre à un alignement de position, et des seconds moyens de traitement (30) pour diviser chacune des dites zones d'image partielles en n x m segments d'image (P_{ij}, Q_{ij}), disposées sous forme matricielle, où n et m sont des entiers positifs, caractérisé en ce que le dit appareil comporte de plus :
des troisièmes moyens de traitement (40) :
dans un premier mode, pour sélectionner un segment d'image initial (P_{ij}) de la première image ;
pour détecter le défaut d'alignement entre le dit segment d'image initiel (P_{ij}) et un certain nombre de segments d'image (Q_{ij}) de le dite seconde image en utilisant un premier paramètre d'évaluation basé sur des données de coefficient de corrélation pour sélectionner un segment d'image optimal (Q_{ij}') présentant un coefficient de corrélation maximum donné ;
dans un second mode, pour détecter le défaut d'alignement entre le dit segment d'image initial (P_{ij}) et un certain nombre de segments d'image légèrement décalés par rapport au dit segment d'image optimal (Q_{ij}') en utilisant un second paramètre d'évaluation basé sur des données de différences de densités de pixel et des données de coefficient de corrélation pour sélectionner le paire de segments d'image optimaux (P_{ij}, Q_{ij}") présentant une fonction d'évaluation maximale (Pxy) ;
pour sélectionner un segment d'image initial supplémentaire ($P_{i+1,\ j}$) et en répétant la dite détection dans les dits premier et second modes ;
pour stocker des données de défaut d'alignement pour chacun des (P_{ij}) ; et
des quatrièmes moyens de traitement (50) pour sélectionner au moins une paire de segments d'image optimaux (P_{ij}, Q_{ij}") présentant les données de défaut d'alignement optimal et pour aligner les dites première et seconde images sur la base des dites données de défaut d'alignement optimal.

2. Appareil selon la revendication 1, caractérisé en ce que les dits troisièmes moyens de traitement comportent :
des premiers moyens de calcul (80) pour calculer séquentiellement les dites données de coefficient de corrélation quand le dit premier mode de détection est exécuté, en décalant au moins l'une des dites paires de segments d'image correspondantes autour d'une position initiale dans un plan d'image d'une manière telle que chaque décalage à partir de la dite position initiale place les segments d'image avant et après le décalage en recouvrements partiels relatifs ; et
des premiers moyens (90) de détection d'un maximum pour déterminer les données de corrélation maximale parmi plusieurs blocs des dites données de corrélation calculées pour chaque paire des dits segments d'image correspondants.

3. Appareil selon le revendication 2, caractérisé en ce que les dits troisièmes moyens de traitement comportent de plus :
des moyens (100) de commande du mode, connectés aux dits premiers moyens (90) de détection du maximum pour mémoriser électriquement une valeur de seuil des dites données de corrélation et pour commuter le mode de détection du dit premier au dit second mode de détection quand une variation dans les données de corrélation entre les dites paires de segments d'image, détectée séquentiellement, diminue jusqu'à retomber à la dite valeur de seuil.

4. Appareil selon le revendication 3, caractérisé en ce que les dits troisièmes moyens de traitement comporte de plus :
des seconds moyens (82) de calcul pour ajouter les amplitudes des différences de densités de pixel pour chacune des dites paires de segments d'image dans le dit second mode de détection pour produire les dites données de différences de densités de pixel ;
des moyens (112, 114) de normalisation, connectés aux dits premiers moyens (80) de calcul et aux dits seconds moyens (82) de calcul, pour normaliser les dites données de corrélation et les dites données de différences de densités ; et
des troisièmes moyens (116) de calcul, connectés aux dits moyens (112, 114) de normalisation, pour calculer le dit second paramètre d'évaluation basé sur les dites données de corrélation normalisées et les dites données de différences de densités de pixel.

5. Appareil selon la revendication 4, caractérisé en ce que les dits troisièmes moyens de traitement comportent de plus :
des seconds moyens (120) de détection d'un maximum pour mettre à jour le dit second paramètre d'évaluation pour déterminer le maximum dans une pluralité des dits seconds paramètres d'évaluation calculés pour la paire

particulière de segments d'image ; des moyens (124, 130) de terminaison de mode, couplés aux dits seconds moyens (120) de détection du maximum, pour mémoriser électriquement une valeur de seuil du dit second paramètre d'évaluation et pour terminer le dit second mode de détection exécuté pour la paire particulière de segments d'image par les dits troisièmes moyens de traitement (40) quand le dit second paramètre d'évaluation mis à jour excède la dite valeur de seuil ; et des quatrièmes moyens (96) de calcul pour détecter les adresses du centre de chacune des dites paires de segments d'image optimaux et pour calculer un défaut d'alignement entre les dites adresses de centre.

6. Appareil selon la revendication 5, caractérisé en ce qu'il comporte de plus des cinquièmes moyens (148) de traitement pour trier les données de corrélation finales et les données de différences de densités de pixel, qui sont obtenues respectivement dans les dits premier et second modes de détection pour les dites paires particulière et optimale de segments d'image des dites zones d'image partielles, pour chercher chacune des dites paires particulière et optimale de segments d'image pour au moins une paire de segments d'image ayant à la fois des données de corrélation et des données de différences de densités de pixel classées dans un rang d'ordre élevé et pour calculer un vecteur de défaut d'alignement entre au moins la dite paire de segments d'image.

7. Appareil selon la revendication 6, caractérisé en ce que les dits cinquièmes moyens (148) de traitement comportent : une première mémoire hiérarchique (154) pour mémoriser la dite pluralité de blocs de données de corrélation finale pour l'ensemble des dites paires particulières de segments d'image en ordre de la plus grande à la plus petite ; une seconde mémoire hiérarchique (156) pour mémoriser la dite pluralité de blocs de données de différence de densités de pixel finale pour l'ensemble des dites paires optimales de segments d'image en ordre de la plus grande à la plus petite ; et des circuits (158, 160, 162) couplés aux dites première et seconde mémoires hiérarchiques pour extraire au moins une paire de segments d'image, dont les données de corrélation et les données de différences de densités de pixel sont en même temps dans un rang particulier élevé et pour déterminer des données vectorielles de défaut d'alignement d'au moins une paire de segments d'image.

8. Procédé de traitement d'images pour aligner une paire de première et seconde images, comprenant des étapes d'extraire une zone d'image partielle désirée de chacune des première et seconde images à aligner, et de diviser chacune des dites zones d'image partielles en n x m segments d'image (P_{ij}, Q_{ij}), disposées sous forme matricielle, où n et m sont des entiers positifs, caractérisé en ce qu'il comporte de plus les étapes de : dans un premier mode, de sélectionner un segment d'image initial (P_{ij}) de la première image ; de détecter le défaut d'alignement entre le dit segment d'image initial (P_{ij}) et un certain nombre de segments d'image (Q_{ij}) de la dite seconde image en utilisant un premier paramètre d'évaluation basé sur des données de coefficient de corrélation pour sélectionner un segment d'image optimal (Q_{ij}') présentant un coefficient de corrélation maximum donné ; dans un second mode, de détecter le défaut d'alignement entre le dit segment d'image initial (P_{ij}) et un certain nombre de segments d'image légèrement décalés par rapport au dit segment d'image optimal (Q_{ij}') en utilisant un second paramètre d'évaluation basé sur des données de différences de densités de pixel et des données de coefficient de corrélation pour sélectionner la paire de segments d'image optimaux (P_{ij}, Q_{ij}'') présentant une fonction d'évaluation maximale (Pxy) ; de sélectionner un segment d'image initial supplémentaire $P_{i+1,\ j}$) et en répétant le dite détection dans les dits premier et second modes ; de stocker des données de défaut d'alignement pour chacun des (P_{ij}) ; et de sélectionner au moins une paire de segments d'image optimaux (P_{ij}, Q_{ij}'') présentant les données de défaut d'alignement optimal et pour aligner les dites première et seconde images sur la base des dites données de défaut d'alignement optimal.

9. Procédé selon la revendication 8, caractérisé en ce qu'il comporte de plus une étape de réalisation répétée des dites première et seconde détections de défaut d'alignement pour les paires de segments d'image autres que la dite paire sélectionnée de segments d'image, fournissant ainsi des données vectorielles de défaut d'alignement final pour toutes les dites paires de segments d'image incluses dans les dites zones d'image partielles des dites première et seconde images.

10. Procédé selon la revendication 9, caractérisé

en ce qu'il comporte de plus les étapes de : trier séparément une pluralité de blocs de données de corrélation finale et des données de différences de densités de pixel obtenues pour toutes les dites paires de segments d'image ; chercher chacune des dites paires de segments d'image pour au moins une paire de segments d'image présentant ces données de corrélation et ces données de différences de densités de pixel qui sont chacune à un rang élevé prédéterminé ; et spécifier la quantité de défaut d'alignement entre au moins une des dites paire de segments d'image comme données de défaut d'alignement hautement fiables et pour utiliser la dite quantité de défaut d'alignement spécifiée pour aligner les dites première et seconde images.

11. Procédé selon le revendication 9, caractérisé en ce qu'il comporte de plus les étapes de : trier les dites données finales de corrélation dans l'ordre de le plus grande à le plus petite pour former une structure hiérarchique des dites données de corrélation ; trier les dites données finales de différences de densités de pixel dans l'ordre de la plus petite à le plus grande pour former une structure hiérarchique des dites données de différences de densités de pixel ; chercher chacune des dites paires de segments d'image pour au moins une paire de segments d'image présentant ces données de corrélation et ces données de différences de densités de pixel qui sont toutes à un rang élevé prédéterminé ; et de spécifier la quantité de défaut d'alignement entre au moins la dite paire de segments d'image comme données de défaut d'alignement hautement fiables et pour utiliser la dite quantité de défaut d'alignement spécifiée pour aligner les dites première et seconde images.

Ansprüche

1. Bildverarbeitungssystem zur Ausrichtung eines Paars von ersten und zweiten Bildern, mit einer ersten Prozessoreinheit (14) zum Ausziehen bzw. Aussieben eines gewünschten Teilbildbereichs aus jedem der ersten und zweiten, der Lagenausrichtung zu unterwerfenden Bilder und einer zweiten Prozessoreinheit (30) zum Teilen oder Dividieren jedes der Teilbildbereiche in n x m Bildsegment (P_{ij}, Q_{ij}), die in einer Matrixform angeordnet sind, wobei n und m jeweils positive ganze Zahlen darstellen, gekennzeichnet durch
eine dritte Prozessoreinheit (40), um
in einem ersten Modus ein Anfangsbildsegment (P_{ij}) des ersten Bilds zu wählen,
um eine Fehlausrichtung zwischen dem Anfangsbildsegment (P_{ij}) und einer Anzahl von Bildsegmenten (Q_{ij}) des zweiten Bilds unter Benutzung eines ersten Bewertungsparameters auf der Grundlage von Korrelationskoeffizientdaten für das Wählen eines optimalen Bildsegmentes (Q_{ij}') eines gegebenen maximalen Korrelationskoeffizienten zu detektieren,
um in einem zweiten Modus eine Fehlausrichtung zwischen dem Anfangsbildsegment (P_{ij}) und einer Anzahl von um das optimale Bildsegment (Q_{ij}) feinverschobenen Bildsegmenten unter Benutzung eines zweiten Bewertungsparameters auf der Grundlage von Pixeldichte-Differenzdaten und Korrelationskoeffizientdaten für das Wählen des optimalen Segmentpaars (P_{ij}, Q_{ij}') mit einer maximalen Bewertungsfunktion (Pxy) zu detektieren, um ein weiteres Anfangsbildsegment ($P_{i+1,\ j}$)zu wählen und die Detektion in erstem und zweitem Modus zu wiederholen, sowie um Fehlausrichtungsdaten für jedes Segment (P_{ij}) zu speichern, und
eine vierte Prozessoreinheit (50) zum Wählen mindestens eines optimalen Bildsegmentpaars (P_{ij}, Q_{ij}'') mit den optimalen Fehlausrichtungsdaten und zum Ausrichten der ersten und zweiten Bilder auf der Grundlage der optimalen Fehlausrichtungsdaten.

2. System nach Anspruch 1, dadurch gekennzeichnet, daß die dritte Prozessoreinheit umfaßt:
eine erste Recheneinheit (80) zum sequentiellen Berechnen der Korrelationskoeffizientdaten bei Durchführung des ersten Detektionsmodus durch Verschieben mindestens eines der betreffenden Bildsegmentpaare um eine Anfangsposition auf einer Bildebene herum in der Weise, daß bei jeder Verschiebung aus der Anfangsposition die Bildsegmente vor und nach dem Verschieben gewisse Überlappungsabschnitte zwischen sich aufweisen, und eine erste Maximumdetektoreinheit (90) zum Bestimmen der maximalen Korrelationsdaten unter einer Vielzahl von Einheiten der für jedes Paar der betreffenden Bildsegmente berechneten Korrelationsdaten.

3. System nach Anspruch 2, dadurch gekennzeichnet, daß die dritte Prozessoreinheit ferner umfaßt:
eine mit der ersten Maximumdetektoreinheit (90) verbundene Modussteuereinheit (100) zum elektrischen Speichern eines Schwellenwerts der Korrelationsdaten und zum Umschalten

des Detektionsmodus vom ersten Detektionsmodus auf den zweiten Detektionsmodus, wenn eine Änderung in den Korrelationsdaten zwischen den Bildsegmentpaaren, sequentiell detektiert, abnimmt und unter den Schwellenwert fällt.

4. System nach Anspruch 3, dadurch gekennzeichnet, daß die dritte Prozessoreinheit ferner umfaßt:
eine zweite Recheneinheit (82) zum Summieren der Größen der Pixeldichtedifferenzen für jedes der Bildsegmentpaare im zweiten Detektionsmodus zwecks Lieferung von Pixeldichtedifferenzdaten,
eine mit erster Recheneinheit (80) und zweiter Recheneinheit (82) verbundene Normiereinheit (112, 114) zum Normieren der Korrelationsdaten und der Pixeldichtedifferenzdaten sowie
eine mit der Normiereinheit (112, 114) verbundene dritte Recheneinheit (116) zum Berechnen des zweiten Bewertungsparameters auf der Grundlage der normierten Korrelationsdaten und Pixeldichtedifferenzdaten.

5. System nach Anspruch 4, dadurch gekennzeichnet, daß die dritte Prozessoreinheit ferner umfaßt:
eine zweite Maximumdetektoreinheit (120) zum Aktualisieren des zweiten Bewertungsparameters zwecks Bestimmung des Maximums unter einer Vielzahl der für das spezielle Bildsegmentpaar berechneten Bewertungsparameter,
eine mit der zweiten Maximumdetektoreinheit (120) gekoppelte Modusbeendigungseinheit (124, 130) zum elektrischen Speichern eines Schwellenwerts des zweiten Bewertungsparameters und zum Beendigen des für das spezielle Bildsegmentpaar durch die dritte Prozessoreinheit (40) durchgeführten zweiten Detektionsmodus, wenn der aktualisierte zweite Bewertungsparameter den Schwellenwert übersteigt, und
eine vierte Recheneinheit (96) zum Detektieren von Mittenadressen von jedem der optimalen Bildsegmentpaare sowie zum Berechnen einer Fehlausrichtung zwischen den Mittenadressen.

6. System nach Anspruch 5, gekennzeichnet durch eine fünfte Prozessoreinheit (148) zum Sortieren endgültiger Korrelationsdaten und Pixeldichtedifferenzdaten, die jeweils in erstem bzw. zweitem Detektionsmodus für die speziellen und optimalen Segmentpaare der Teilbildbereiche gewonnen oder ermittelt werden, zum Absuchen aller speziellen und optimalen Bildsegmentpaare nach mindestens einem Bildsegmentpaar mit sowohl Korrelationsdaten als auch Pixeldichtedifferenzdaten eines hohen Rangs sowie zum Berechnen eines Fehlausrichtungsvektors zwischen dem mindestens einen Bildsegmentpaar.

7. System nach Anspruch 6, dadurch gekennzeichnet, daß die fünfte Prozessoreinheit (148) umfaßt:
einen ersten hierarchischen Speicher (154) zum Speichern der zahlreichen Einheiten endgültiger Korrelationsdaten für alle speziellen Bildsegmentpaare in der Reihenfolge von den größten zu den kleinsten Daten,
einen zweiten hierarchischen Speicher (156) zum Speichern der zahlreichen Einheiten der endgültigen Pixeldichtedifferenzdaten für alle optimalen Bildsegmentpaare in der Reihenfolge von den kleinsten zu den größten Daten sowie
eine mit erstem und zweitem hierarchischen Speicher gekoppelte Schaltungseinrichtung (158, 160, 162) zum Ausziehen bzw. Aussieben mindestens eines Bildsegmentpaars, bei dem die Korrelationsdaten und die Pixeldichtedifferenzdaten jeweils mit einem spezifischen hohen Rang vorliegen, und zum Bezeichnen von Fehlausrichtungsvektordaten des mindestens einen Bildsegmentpaars.

8. Bildverarbeitungsverfahren zum Ausrichten eines Paars von ersten und zweiten Bildern, umfassend die Schritte des Ausziehens bzw. Aussiebens eines gewünschten Teilbildbereichs aus jedem der auszurichtenden ersten und zweiten Bilder und des Teilens oder Dividierens jedes der Teilbildbereiche in n x m Bildsegmente (P_{ij},Q_{ij}), die in einer Matrixform angeordnet sind, wobei n und m positive ganze Zahlen darstellen, dadurch gekennzeichnet, daß
in einem ersten Modus ein Anfangsbildsegment (P_{ij}) des ersten Bilds gewählt wird,
eine Fehlausrichtung zwischen dem Anfangsbildsegment (P_{ij}) und einer Anzahl von Bildsegmenten (Q_{ij}) des zweiten Bilds unter Benutzung eines ersten Bewertungsparameters auf der Grundlage von Korrelationskoeffizientdaten für das Wählen eines optimalen Bildsegmentes (Q_{ij}') eines gegebenen maximalen Korrelationskoeffizienten detektiert wird,
in einem zweiten Modus eine Fehlausrichtung zwischen dem Anfangsbildsegment (P_{ij}) und einer Anzahl von um das optimale Bildsegment (Q_{ij}') feinverschobenen Bildsegmenten unter Benutzung eines zweiten Bewertungsparameters auf der Grundlage von Pixeldichte-Differenzdaten und Korrelationskoeffizientdaten für das Wählen des optimalen Segmentpaars (P_{ij},

Q_{ij}') mit einer maximalen Bewertungsfunktion (Pxy) detektiert wird, ein weiteres Anfangsbildsegment ($P_{i+1,\ j}$) gewählt und die Detektion in erstem und zweiten Modus wiederholt werden, Fehlausrichtungsdaten für jedes Segment (P_{ij}) gespeichert werden und
mindestens ein optimales Bildsegmentpaar (P_{ij}, Q_{ij}'') mit den optimalen Fehlausrichtungsdaten gewählt und die ersten und zweiten Bilder auf der Grundlage der optimalen Fehlausrichtungsdaten ausgerichtet werden.

9. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß die ersten und zweiten Fehlausrichtungsdetektionen für das vom gewählten Bildsegmentpaar verschiedene Bildsegmentpaar wiederholt durchgeführt werden, um damit endgültige Fehleusrichtungsvektordeten für alle der n x m Bildsegmentpaare innerhelb der Teilbildbereiche der ersten und zweiten Bilder zu liefern.

10. Verfehren nech Anspruch 9, dadurch gekennzeichnet, daß zahlreiche Einheiten von für elle der Bildsegmentpeere erheltenen endgültigen Korrelationsdeten und Pixeldichtedifferenzdaten getrennt sortiert werden, alle der Bildsegmentpeare auf mindestens eln Bildsegmentpeer mit diesen Korrelationsdeten und Pixeldichtedifferenzdeten, die beide in einem vorbestimmten hohen Rang vorliegen, abgesucht werden und
die Fehlausrichtungsgröße zwischen dem mindestens einen Bildsegmentpaar als höchst zuverlässige Fehlausrichtungsdaten bezeichnet und die bezeichnete Fehlausrichtungsgröße für die Ausrichtung der ersten und zweiten Bilder benutzt werden.

11. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß die endgültigen Korrelationsdaten in der Reihenfolge von den größten zu den kleinsten Daten sortiert werden, um eine hierarchische Struktur für die Korrelationsdaten zu bilden,
die endgültigen Pixeldichtedifferenzdaten in der Reihenfolge von den kleinsten zu den größten Daten sortiert werden, um eine hierarchische Struktur für die Pixeldichtedifferenzdaten zu bilden,
alle diese Bildsegmentpaare auf mindestens ein Bildsegmentpaar mit diesen Korrelationsdaten und Pixeldichtedifferenzdaten, die beide in einem vorbestimmten hohen Rang vorliegen, abgesucht werden und die Fehlausrichtungsgröße zwischen dem mindestens einen Bildsegmentpaar als höchst zuverlässige Fehlausrichtungsdaten bezeichnet und die bezeichnete Fehlausrichtungsgröße für die Ausrichtung der ersten und zweiten Bilder benutzt werden.

FIG. 1

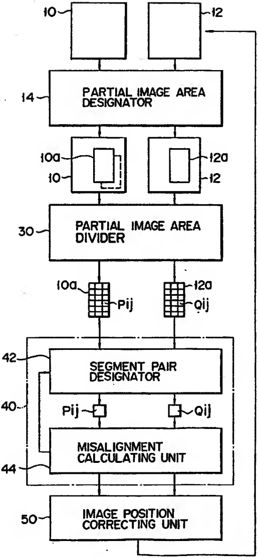
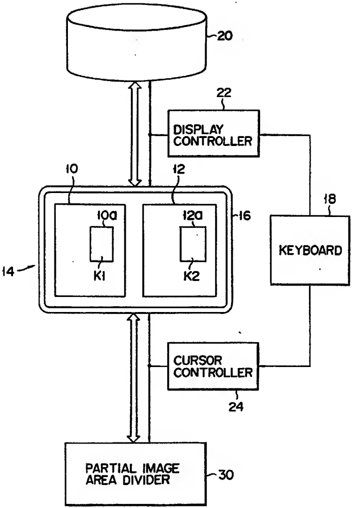

10
12
14
PARTIAL IMAGE AREA DESIGNATOR
10a
10
12a
12
30
PARTIAL IMAGE AREA DIVIDER
10a
Pij
12a
Qij
42
SEGMENT PAIR DESIGNATOR
40
Pij
Qij
MISALIGNMENT CALCULATING UNIT
44
50
IMAGE POSITION CORRECTING UNIT

FIG. 2


20
22
DISPLAY CONTROLLER
10
12
10a
12a
16
18
KEYBOARD
14
K1
K2
CURSOR CONTROLLER
24
PARTIAL IMAGE AREA DIVIDER
30

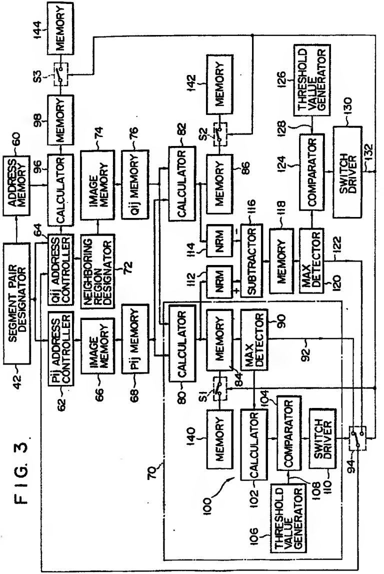
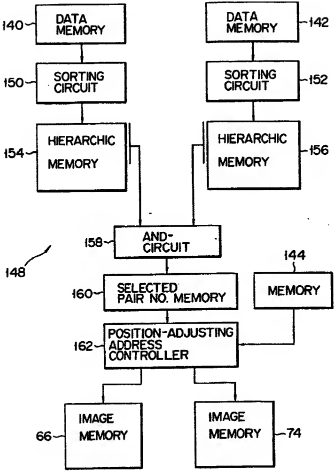

SEGMENT PAIR DESIGNATOR
42
ADDRESS MEMORY
60
Pij ADDRESS CONTROLLER
62
Qij ADDRESS CONTROLLER
64
CALCULATOR
96
MEMORY
98
S3
MEMORY
144
IMAGE MEMORY
66
NEIGHBORING REGION DESIGNATOR
72
IMAGE MEMORY
74
Pij MEMORY
68
Qij MEMORY
76
CALCULATOR
80
CALCULATOR
82
MEMORY
84
MAX DETECTOR
90
92
NRM
112
NRM
114
SUBTRACTOR
116
MEMORY
86
S2
MEMORY
142
MEMORY
118
MAX DETECTOR
120
122
COMPARATOR
124
128
THRESHOLD VALUE GENERATOR
126
SWITCH DRIVER
130
132
S1
MEMORY
140
CALCULATOR
102
COMPARATOR
104
THRESHOLD VALUE GENERATOR
106
108
SWITCH DRIVER
110
94
100
70

FIG. 3

F I G. 4


140
DATA MEMORY
142
DATA MEMORY
150
SORTING CIRCUIT
152
SORTING CIRCUIT
154
HIERARCHIC MEMORY
156
HIERARCHIC MEMORY
158
AND-CIRCUIT
148
144
MEMORY
160
SELECTED PAIR NO. MEMORY
162
POSITION-ADJUSTING ADDRESS CONTROLLER
66
IMAGE MEMORY
74
IMAGE MEMORY